National Center for Computational Sciences Snapshot September 11, 2006

Science Highlights

Recently at the National Center for Computational Sciences (NCCS), researchers using the Cray XT3 (Jaguar) have run some extremely large simulations and achieved exciting results. Using Leadership Computing Facility (LCF) allocations for W.W. Lee’s “Gyrokinetic Plasma Simulation” project and code developed by the research team, the scientists were able to run their gyrokinetic toroidal code (GTC) simulations on 4,800 processors (92% of Jaguar’s 5,212-processor capacity) using 28 billion particles, making it one of the largest fusion simulations ever conducted. The news of this large simulation was originally shared in the June 26 Snapshot. The results of the simulation provide important new insights into the dynamical evolution of turbulence in fusion plasmas.

Random electrostatic fluctuations driven by plasma pressure gradients can cause substantial heat transport by forming finger-like structures (streamers) along the gradient direction. The previous gyrokinetic particle simulation performed by Lee’s team found that fluctuation energy can flow from an unstable region to a stable region. This spreading of turbulence introduces a nonlocal effect and thus determines the dependence of the transport level on the device size. The size scaling of the heat transport is a critical issue in plasma confinement since predicting the performance of future large fusion reactors, such as the International Thermonuclear Experimental Reactor (ITER), is based on an extrapolation from the existing, smaller fusion devices. Therefore, it is important to understand the physics of turbulence spreading that underlies the size scaling of the heat transport.

The new simulation takes advantage of the power that Jaguar provides to use more realistic plasma parameters with a bigger device size. As a result, the dynamical range in the turbulence system is increased to allow a clear scale separation between the turbulence eddy size and the device size. The results of the simulation show that small-scale turbulence eddies are typically generated in the unstable region and flow along the streamers to the stable region. In addition, the streamers are found to break and reconnect, resulting in a very complex dynamical evolution. These new results have raised intense interest in the fusion theory community in the fundamental physics of turbulence spreading and are being prepared for publication.

Research team member Zhihong Lin, from the University of California, Irvine, credits the combined efforts of the research team, NCCS staff, and the computing resources of the NCCS for the recent success. Lin says, “Such a large-scale simulation requires excellent scalability of the GTC code and stable operation of the computer at Oak Ridge National Laboratory (ORNL) and was only made possible with the dedication and expertise of computational scientists, especially Dr. Stephane Ethier of the Princeton Plasma Physics Laboratory and Dr. Scott Klasky of ORNL, and with the support of the DOE SciDAC Center for Gyrokinetic Particle Simulation of Turbulent Transport in Burning Plasmas.”

NCCS Systems

Staff at the NCCS crossed a significant milestone recently in preparing for the laboratory's petaflop computers of the future.

On August 24, the NCCS Technology Integration Group became the first to successfully enable an InfiniBand interface installed in a Cray XT3 system—specifically the Center's Rizzo development system. Using a single InfiniBand adapter, group member Makia Minich was able to sustain transfer rates of more than 880 megabytes per second between the Cray system and a remote node on the InfiniBand fabric.

The achievement is a significant step along the Center's LCF roadmap. To support upcoming 250-teraflop and 1-petaflop computers, the NCCS must be able to transfer data between systems at hundreds of gigabytes per second—more than 10,000 times faster than a typical home computer network. The InfiniBand technology is a good fit for the Center's needs as it supports fast links (10 to 20 gigabits per link) and can be scaled to large networks with thousands of links.

This initial demonstration shows that the InfiniBand approach is viable. Future efforts will focus on connecting a central Lustre file system with the premier Jaguar computer and other NCCS computers using InfiniBand.